A FIRE ALARM CHECK LIST
AND GUIDELINE FOR PLAN REVIEWERS

EXECUTIVE DEVELOPMENT

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ABSTRACT

Cheyenne's Fire Prevention Bureau (FPB) does not have a standard procedure for the review of fire alarm plans. The bureau recognized that it was experiencing to many false fire alarms because of this.

The purpose of this research project was to develop a review checklist and guide for plan reviewers.

The action research method was employed to answer the following questions:

1. What statutory codes, standards or rules apply to fire alarm system design and installation?
2. What specialized training or certification requirements should be required for a fire alarm system: (a) designer, (b) plan reviewer, (c) contractor, (d) installer and (e) monitoring service companies?
3. How are the types of fire alarm systems to be installed in different occupancy classes determined?
4. What constitutes a complete and reliable fire alarm system?
5. Which elements of fire alarm system design have the greatest potential to be misapplied?

The procedures used to complete the research included a literature review of fire service journals, magazines, and textbooks, relating to fire alarm systems. A review of State Statute relating to the authority of the State Fire Marshal's Office and Statute concerning Architecture, City Code in relation to chapter 17 Fire Prevention, fire department rules and records concerning fire alarm systems, rules of the Contractor's Licensing Board concerning licensing of fire alarm contractors. Personal interviews with professional fire protection specialist, designers, installers, and a monitoring company were conducted. The result of the project was the creation of a fire alarm plan review checklist and guide.

Recommendations were to implement the use of the checklist and guide, with a review and evaluation of this process to be made after one year. Fire alarm technical training was to be provided to each fire inspector that might be reviewing the fire alarm plans. Future plans are to have the plan reviewer become certified at some point in the future.

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INTRODUCTION

The Cheyenne Fire Department's Fire Prevention Bureau (FPB) does not have a standard procedure for the review of fire alarm plans. Lack of an established policy regarding fire alarm systems posed difficulties for the person responsible for performing the review. This was compounded by the fact that both building owners and contractors were often provided conflicting information concerning fire alarm requirements from the Bureau.

The purpose of this research project was to develop a review checklist and guide for plan reviewers to utilize when conducting fire alarm plan reviews. The action research method was employed to answer the following questions:

1. What statutory codes, standards or rules apply to fire alarm system design and installation?

2. What specialized training or certification requirements should be required for a fire alarm system: (a) designer, (b) plan reviewer, (c) contractor, (d) installer and (e) monitoring service companies?

3. How are the types of fire alarm systems to be installed in different occupancy classes determined?

4. What constitutes a complete and reliable fire alarm system?

5. Which elements of fire alarm system design have the greatest potential to be misapplied?

The procedures used to complete this research were a literature review of fire service journals, magazines, and textbooks, a review of City of Cheyenne documents and records, a review of statutory requirements concerning fire alarm systems, interviews with fire alarm systems technical specialist.

Results

A fire alarm checklist and guideline was developed for the Cheyenne Fire Department (CFD).

Recommendations

The checklist and guideline should be implemented and a follow up evaluation performed after one year. All inspectors of the department should attend fire alarm training courses. At some point in time the plan reviewer should become International Council of Building Officials (ICBO) certified. In the future, the CFD should research the option of hiring a Fire Protection Engineering Technician. Someone who is already trained, to fill the plan review position, and who could also assist with the technical fire protection systems may prove to be a more wise use of money and manpower.

BACKGROUND AND SIGNIFICANCE

The 911 communications center was experiencing an increased workload caused by new and diverse detection systems. The shortage of personnel was making it more challenging to develop written instructions and checklist or guidelines were not in existence. From 1979 until 1995, the plan reviewer from the fire department was expected to perform fire alarm plan reviews utilizing the Uniform Fire Code (UFC) and other Uniform Codes, in conjunction with NFPA 72, the Fire Alarm Code. The reviewer received “On the Job Training” and if time permitted, would if accepted, attend the National Fire Academy’s (NFA) course or courses for fire inspector and plan review, according to Chief Piester. Because of a lack of knowledge and the complexity of the fire code’s requirements, the department’s plan reviewer has continued to pass down the same problematic procedures concerning fire alarm systems review. This in turn has affected the system's installations.

Historically only limited numbers of the department's firefighters have been interested in a career in the FPB. Because of the workload and the lack of comparable compensation under the department's contract. The Bureau has been use to having the injured or persons near retirement seek promotion. It generally takes an individual four or five years to acquire enough training and background experience in code enforcement, construction plans review, fire investigation and related fields to be able to function independently in the FPB. In addition, years of specialized training and education are required to acquire knowledge in the specialized areas of fire protective systems such as fire alarms systems. There has been a great responsibility placed on the person responsible for conducting the plan review on these systems.

The author, who has a masters electrical license and work related background in the installation of fire alarm systems was promoted to, City Fire Marshal in 1995. The author found that the Bureau had not properly identified all of the problems relating to fire alarm plan reviews and other requirements concerning these systems. Efforts to correct the procedural process of the department's requirements in fire alarm systems design, review, installation and maintenance have been on going since 1996. The rules for licensing of fire alarm contractors and installers in the past were very lenient. All that was required was a State Electrical License or a State Low Voltage License to perform work on fire alarm systems. (City Contractor's Licensing Board rules) Testing for this license consisted of only a few questions relating to fire alarm codes or system installation. The questions were very general in nature and covered only code applications from the National Fire Protection Association's (NFPA) electrical code, NFPA 70. Test questions came exclusively from the section concerning fire alarm wiring. There were no questions in the examination regarding fire alarm appliance installation location requirements or fire alarm code application.

Licensing requirements for fire alarm contractors and installers were changed by the author in 1997 under the Contractors Licensing Board's rules. The rule change was approved by City Ordinance. All fire alarm contractors and installers must now pass a City fire alarm examination written by the author and administered by the Board. The 50 examination questions came directly from NFPA 72, the fire alarm code, the Uniform Fire Code and applicable City fire ordinances.

A City ordinance was proposed and passed in 1997 concerning the method in which fire alarm systems are to be monitored. A dedicated direct telephone line, using reverse polarity is being utilized to monitor all fire alarm systems. The fire alarms are monitored at the City's 911 Emergency Center, by their dispatchers. There wasn't until this time a legal basis establishing this as a requirement. New problems concerning the monitoring service availability of the type of phone utility service lines are now becoming evident. The Wyoming Public Service Commission's contract with then, U. S. West, now Quest did not specify the type of utility service wiring to be installed to monitor these alarms. In the newer areas of town, the telephone utility service being installed is fiber optic. This requires the use of a phone dialer appliance to transmit the fire alarm signal to the monitoring site. The phone dialer appliance is something that the fire chief has specified he will not accept.

In the early 1990s Australia's Telephone Company upgraded its copper network to use fiber optic links and other derived carriers. Many fire alarm networks required the metallic link to power the alarm signaling equipment. The City of San Clemente, California…The City Dispatch Center utilizes one digital alarm receiver and one direct-wire alarm receiver. The digital system, using digital signals over the public telephone network, can provide more information about an emergency, while the direct-wire system provides a more secure communications link. (Reckinger, 1989) APCO BULLETIN November 1089 pg. 57

Expensive upgrades to maintain the monitoring service and the use of dedicated point-to-point links were inconsistent with the telephone network's pricing strategy…p. 28, Cheyenne uses this same outdated technology for its monitoring and is currently facing the problems that the change to dialers to transmit the alarm signal will create.

In 1998 the newer developments in town that have fire alarm system requirements, could not utilize the existing phone cables to monitor their fire alarm systems. The monitoring equipment at the 911 Center would not integrate with a phone dialer. The monitoring system would require an expensive upgrade according to Dave Weekly, the owner of Laramie Fire Protection, the company who monitors fire alarms through the 911 Center. A new fire alarm rule for monitoring of only those areas of the City with fiber optic cable was written by the author. The rule allowed the fire alarm systems in the new developments with fiber optic cable to be monitored by Listed Central Station Monitoring Companies that were approved by the FPB.

No specialized training on fire alarm systems or knowledge of the codes was required as a prerequisite for reviewing the submitted fire alarm plans. The fire alarm designer wasn't required to be certified. Wyoming State Statute (WY SS) requires, according to the State Fire Marshal's Assistant (SFMA), Dubay, that all construction plans submitted contain a stamp from a licensed professional engineer registered in the State of Wyoming. D. Dubay (personal communication, April, 1999). This statute was however seldom enforced by the City's, Chief Building Official. If submitted the fire alarm plans that reached the FPB's plan reviewer were seldom rejected, even if the fire alarm plans were incomplete. This was because of a lack of knowledge of the fire alarm a code requirement. Past plan reviewers had received no formal training in the area of fire alarm systems and weren't certified plan reviewers. It has been a learn as you go type of process. The author informed the Building Official in writing in 1997 that the fire department would allow NICET level III fire alarm technicians to submit fire alarm plans for review.

Recently, the person conducting the plan reviews retired. The problem for the new plan reviewers is the lack of a standard method in the review of fire alarm systems. With out a plan review checklist and guideline for fire alarm systems, the review of the fire alarm plans submitted would be subject to the discretion of whichever the reviewer is. A prerequisite requirement for certification of the plan reviewer is unrealistic at this time. The affect of allowing this problem to continue will have a negative impact possibly allowing improperly designed fire alarm systems to be installed in the jurisdiction.

The credibility of the organization, concerning all fire alarm systems will be the benefit of this project. The checklist and guide should help to ensure that all department plan reviewers conduct a standardized review of all fire alarm plans. The review process should reduce the number of false or mistaken fire alarms. An additional benefit to the department will be the reduced chance for fire department apparatus to become involved in possible vehicle accidents during the alarm response.

This project was undertaken in part to satisfy requirements for the National Fire Academy (NFA) Executive Development Course. Several units were relevant to this project. “Working as a team” from unit 1; “Professional development’ from unit 2, both were important and applicable to the project. “Research” from unit 3 was very important and was instrumental in providing the foundation for process of reviewing and presenting the information in the proper format. “Managing Creativity” from unit 4 and “Organizational Culture” from unit 7 seemed to fit the undertaken project to a tee.

LITERATURE REVIEW

Fire service professionals take significant risks to perform their duties, and they get the immediate satisfaction of knowing that the risks they take pay off in saving human lives. Fire protection design professionals make a contribution no less significant. They are not only responsible for saving lives of people whom they will never meet, they help to significantly lessen the risk to fire service professionals by designing fire protection systems that prevent a fire from getting out of control. (Gagnon, 1997, foreword)

In an interview with SFMA Dubay, Debay was asked what statutory codes apply to fire alarm system design and installation in Wyoming? Dubay replied, WY SS requires a, Wyoming licensed professional engineers stamp to be on every construction print turned in for plan review if design or engineering is performed. (D. Dubay, personal communication, October, 1997)

An architect or landscape architect shall affix his seal to all documents, plans or designs he provides. (Laws 1991, ch. 260, s 1)

The researcher investigated the WY SS and what the legal basis allowing for the enforcement of fire alarm system requirements are and found the following: (a) that the UFC is adopted by WY SS. (b) that the SFM is authorized to issue local municipalities “Home Rule Authority”. (c) statute requires local municipalities to follow the “Administrative Procedure Act” in adoption of ordinances. (d) Cheyenne City Code chapter 17 applies to Fire Prevention with in the jurisdiction of Cheyenne. (e) that the City of Cheyenne is authorized to amend such code by ordinance to a more stringent status as deemed necessary for the local jurisdiction. (f) that the UFC 1997 edition was adopted in May of 1998 by the City Council. (g) that section 1007 UFC 1997 edition applies to fire alarm requirements for the various occupancies listed in this code. (h) that section 1007 UFC references the NFPA 72, the National Fire Alarm Code. (i) that the NFPA 72 code references, NFPA 70 the National Electrical Code, NFPA 13 the National Fire Sprinkler Code, and NFPA 170 Symbols for Construction Design. (j) that the Contractor’s Licensing Board for the City is appointed by the Mayor and is authorized as such to set rules for all contractors doing business within the City of Cheyenne. (k) that all fire alarm contractors as of 1998 were required and administered a fire alarm written examination by the Licensing Board.

In an interview with the Fire Protection Engineering Technician (FPE Tech) from Pouder Valley Fire Authority, Ron Gonzoles, Gonzoles confirmed that even though Colorado does not have a SFMO that each major fire department in Colorado has adopted the UFC and uses NFPA 72 and 70 in the review of fire alarm design and installation. R. Gonzoles (personal communication, November, 2000)

In an interview with Fire Protection Engineer (FPE), Glen Saraduke from Golden Colorado, Mr. Saraduke said that wherever fire alarm systems are to be designed or installed in the United States a uniform code should be adopted and supplemented by the NFPA 72. G. Saraduke (personal communication, April, 1999)

An interview with Fire Inspector II, Metz with the Orange County Fire Authority in Orange County California, California has adopted the UFC by statute, uses NFPA 72 for design and installation criteria for fire alarm systems. Orange County has a fire alarm checklist and uses it in the fire alarm review. R. Metz (personal communication, March, 1999)

According to Gagnon, The NFPA publishes over 290 codes, standards, recommended practices, and guides that apply to fire safety and the design of fire protections systems. (Gagnon, 1997). Gagnon specifically sites NFPA 72 to be used as a minimum in the design of fire alarm systems.

The review established that the answer to question 1 is, Wyoming State Statute, City of Cheyenne Code, 1997 Uniform Fire Code, NFPA 72 National Fire Alarm Code, NFPA 70 the National Electric Code, NFPA 170 the Standard for Symbols, City Contractor Licensing Board rules, and fire department rules as authorized under the powers in the UFC all apply to fire alarm design and installation requirements.

Gagnon specifies by definition what a fire protection engineer is. That he is qualified by experience and education to perform protection system design. He further defines what fire protection system design is. Fire protection technicians are persons with the knowledge, skill, and training to perform fire protection layout, the act of following the requirements of a standard to execute a drawing using accepted national standards. (Gagnon, 1997, p. 17)

In the interview with Gonzoles he indicated that either a FPE, electrical engineer (EE), engineering tech or a (NICET) level IV tech, who have special training and technical knowledge in fire alarm systems should all be allowed to perform fire alarm system design work. Gonzoles (December 1997)

In the interview with Saraduke, he indicated that only a FPE or professional engineer with training in the field of fire alarms such as an EE is allowed to perform system design. A NICET Level IV certification in fire alarms is nationally recognized to perform fire alarm system design however a Level III technician can perform layout. Any recognized fire alarm system technician should be qualified to perform fire alarm system design or layout, as long as they have the appropriate level of certification. The plans examiner should be trained and knowledgeable in plan review, it lends more credibility to the review if this person is International Conference of Building Officials (ICBO) certified as a plans examiner. G. Saraduke (personal communication, April, 1999)

AFFA, because of its commitment to increasing the reliability and effectiveness of fire alarm systems, supports third-party certification of individual technicians. It believes that the program developed by NICET offers the best means of achieving certification objectives. It supports the adoption of laws, which require that a fire protection engineer or a NICET certified technician take responsibility for the overall design of fire alarm systems. AFFA supports its convictions by currently offering NICET preparatory programs through both its national office and its member associations

> This certification program was designed for engineering technicians working in the fire alarm industry who engage in a combination of the following fire alarm activities: System layout (plan preparation), system equipment selection, system installation, system acceptance testing, system trouble-shooting, system servicing, and system sales.
>
> Technical areas covered include applicable codes and standards, types of signaling systems, supervision requirements, types of fire and smoke detectors, building occupancy considerations, basic electricity and electronics, and physical science fundamentals.
>
> This certification does not entitle the certification to practice engineering. The practice of engineering is defined and regulated by state engineering licensing boards; unlawful practice of engineering is a violation of state laws. (Automatic Fire Alarm Association, Inc., 1994, letter)

Answering question 2 the certification requirements that should be required to perform fire alarm system design were a fire protection engineer, electrical engineer, fire protection engineering technician, NICET level IV technician or NICET level III technician for fire alarm system layout.

Section 1007 – Fire Alarm Systems, specifies in 1007.1.1 Applicability. Installation and maintenance of fire alarm systems shall be in accordance with Section 1007. (Uniform Fire Code, 1997)

The different occupancy classifications in the code list the specification as to the type of fire alarm system that is required; either manual, automatic, or a combination of both.

NFPA 72 (1996) recognizes seven types of fire alarm systems:

1. Household fire alarm systems
2. Protected premises (local) fire alarm systems
3. Emergency voice alarm communication systems
4. Auxiliary (municipal) fire alarm systems
5. Remote supervising station fire alarm systems
6. Central station systems
7. Proprietary supervising station systems

(NFPA 72, 1996, index)

Each system is determined by the method in which the initiation of the alarm signals are monitored or notification is given.

The publication of the Monitoring Network Performance Standard will be the first time that minimum requirements have been specified for fire alarm monitoring in Australia.

SCADA is Supervisory Control and Data Acquisition. A World First SCADA Standard for Fire Alarm Monitoring. (Parsons, 1997)

British Standards Institution drafting committee felt that internal telephone systems should no longer be recommended. “The use of telephones for giving the fire alarm within a building is no longer recommended.” (Northey, 1988)

The Return to Monitoring by Brigades, The right place to monitor fire signals is at brigade controls. New technology solutions are available to make this a much more manageable proposition than days gone by. (Todd, 1988)

Fire departments have continued to monitor fire alarm systems within their respective areas for several different reasons, i.e., quicker fire response, reliability of an efficiently operating alarm system, or lack of any other bonafide receiving agency…(Tibbs, 1991)

An intelligent fire alarm system should ensure detection of a fire as early as possible and eliminate false alarms. It may need to use several kinds of sensors to detect fire components such as smoke, temperature and gas and also to make a fire/nonfire judgment by forecasting changes in the phenomena. (Ishii, H., Muroi, N., 1986)

The recent sale of the Melbourne Fire Brigade's alarm monitoring network to Tyco Fire Monitoring will result in the first implementation of the protocol in Australia. The first 6,500 alarms to be transferred to the new network are expected to occur in mid 1997.

Alarm initiating devices require special circuits to ensure that signaling zone wiring does not unknowingly fail before a fire incident requires the zone to perform. If a wire breaks or one side of the signaling circuit touches the ground, a trouble signal indicates on the fire alarm control panel. (Spahn, 1990)

NFPA 72, list two basic wiring classes for fire alarm systems, Class A and B systems. The Class A system consist of four wires and adds redundancy to the systems level of protection. Specifically the wiring circuit has D.C. current that provides an electrical signal to either the initiating or notification appliance in either direction in the circuit. The Class B system has only two wires and if a wire breaks, or an appliance is removed, appliances down stream from where the interruption of the electrical continuity is will not function. The importance of the fire alarms system's "Classification" is in that redundancy to certain occupancies such as hospitals is added as a safety factor. The cost associated with a Class A fire alarm system is increased but so is the level of protection. (NFPA 72, 1996, pp.72-33)

Answering question 3, the UFC (1997) specifies whether a manual, automatic, or combination of the two systems is to be installed in the particular building occupancy classes. The NFPA 72 (1996) list the monitoring class by the method on notification or monitoring into seven types. The "Authority Having Jurisdiction" (AHJ) specifies the type of monitoring system allowed for the different occupancies, the CFD uses Local, Remote and Central Station systems to monitor.

NFPA list two types of wiring circuits Classes A and B. Class A is a four wire redundant system, B is the normal two wire system, the (AHJ) and designer should consider the types of occupancies that Class A systems are to be installed in. They are more expensive systems due to the redundancy. Information describing the different types of fire alarm within the jurisdiction is a valuable resource that, with additional information such as that discussed below, will assist fire departments in mitigating automatic fire alarms. First of all, you should know which type of fire alarm the occupancy has. (Lobeto A., 1996, p. 93)

The installation of a Fire Alarm System is a very critical aspect of the role played by technology in meeting the challenge of preserving life in a fire situation. Devices and equipment alone do not constitute a system until all component parts are properly inter-connected with electrical wiring. Therefore a more detailed look at pertinent codes and standards is required.

> The Authority Having Jurisdiction will demand that a Verification Report be presented to him prior to his acceptance of the installation. … The verification must be performed by an organization acceptable to the Authority Having Jurisdiction, and by qualified personnel in the employment of that organization.
>
> Certificate of Verification…After the entire system has been verified with no outstanding deficiencies, a certificate confirming the completed project is to be issued. This document normally specifies the date of test completion, location of approved installation, name of installing contractor, name of verifying organization, and is signed by an authorized representative of the company. (Canadian Fire Alarm Association, 1989, pp. 115, 127)
>
> The CFD use a similar verification form called "Certificate of Completion."

According to Saraduke in a phone interview (personal communication, December, 2000) There are four main elements which make a fire alarm system complete and all are necessary to ensure its reliability they are "the system design, equipment appliance application, system installation, system maintenance."

Answering question 4, system design, equipment appliance application, system installation, system maintenance, and devices and equipment interconnected by electrical wiring that has been verified to have no outstanding deficiencies. The system must be verified as being complete by certification.

False alarms, however, are not usually the fault of the detection system or its design. Improper system selection, the random placement of detectors, and other unsophisticated approaches to the detection installation usually cause them. Detector location is one of the key factors in determining the efficiency, performance, and economics of a detector system installation. (Bryan, 1982, p. 320)

Smoke detectors have been a source of significant but needless alarm problems. For about five years prior to January 1985, smoke detectors were required by testing agencies to be more sensitive than previously to products of combustion. This made the units susceptible to sounding alarms from excessive air movements, low levels of products of combustion, and dirt/dust conditions. In January 1985, manufacturers were allowed to increase the level of smoke obscuration causing an alarm by 50 percent. (Carson & Klinker, 1986, p. 6)

When laying out a fire detection system the design engineer must keep in mind the operation characteristics of the individual detector types as they relate to the area protected. Such factors as type and quantity of fuel, possible ignition sources, ranges of ambient conditions and value of the protected property are critical in the proper design of the system. Heat detectors have the lowest cost and false alarm rate but are the slowest in response. Smoke detectors are higher in cost than heat detectors but are faster responding to fires. Due to their greater sensitivity, false alarms can be more frequent, especially if they are not properly located. Smoke detectors do not have a specific space rating except for a 30- foot maximum guide derived from the UL full-scale approval tests, which they must pass. (Bukowski, Custer, Bright, p. 25)

It is impossible to install detection systems at the drawing board according to spacing allowances from the approval listing and have an effective and efficient fire detection system. McGuire (16) indicates that the following factors should be considered in designing an automatic detection system for a particular structure or occupancy:

1. Type of combustion to be expected-whether emphasis should be on detection of flaming or smoldering combustion

2. Activities normally conducted in the building which involve generation of smoke or products of combustion, naked flame, or high energy radiant surfaces

3. Air flow patterns within the region to be protected

4. Tolerable detection delay time

5. Cost

(Bryn, 1982, p. 334)

For household detectors, a recent Fire Administration study found that most detectors are properly located and powered, usually with batteries. As time goes on however, detector sensitivity may degrade and batteries may not be replaced regularly. (McGuire, 1981)

Maintenance problems also affect detector reliability particularly in photo electric and ionization types. Accumulations of dust and films on the bulbs, lenses and photocells will reduce the intensity of light within the detection element. (Bukowski, Custer, Bright, 1978)

A portion of the problem lies in the way we test and approve automatic fire detection devices in the U.S. with our present system, a completely different series of test fires are used for each type of automatic fire detection device. There is no grading of the fire sizes, especially with regards to smoke detectors…

The results, therefore, cannot be intelligently used to compare one detector against another and, consequently, intelligent utilization of the devices can not always be made. (Bright, 1976, pp. 3, 4)

An experimental program has been initiated to map ceiling environments to which fire detectors are exposed for various combinations of room geometry, ceiling configuration, fire type, and detector spacing." The measured environmental parameters included temperature, velocity and optical density. This type of data in table format listing the type of detector the fire material it is tested under and the control requirements will assist designers in the selection of detectors.

> The usual sources of false alarms are excessive air-velocity, humidity, effect of temperature, condensation, dust, radio frequency interference, electromagnetic interference, transients, component failure, and marginal circuit design. (Solomon, 1986, p. 27)

When choosing a detector for a specific location, consideration must be given to the background levels of the signals to which the detector might be exposed under non-fire conditions. It is not likely that false alarms due to localized and transient changes in the ambient levels of fire signals can be completely eliminated.

> Heating and air-conditioning systems in buildings can exert several effects on the placement and operation of detection devices. (Bukowski, Custer, Bright, 1978, pp. 20, 21)

Knowledge of air flow patterns is most important if smoke detectors of both visible and invisible products of combustion are to function properly False alarms, however, are not usually the fault of the detection system or its design. They are usually caused by improper system selection, the random placement of detectors, and other unsophisticated approaches to the detection installation. Detector location is one of the key factors in determining the efficiency, performance, and economics of a detector system installation. This type of detector placement is usually based on structure's construction plans with no consideration for other factors such as thermal barriers from solar exposures, air flow patterns created by heating, air conditioning, and ventilation systems, stack effect influences within the building, the influence of equipment or machinery on air flow or heat output, or the arrangement of ceiling finishes as to lighting, ventilation louvers, or outlets. (Bryan, 1982, p. 335)

The external wiring to initiating circuits is not always recognized as a source of false alarms. All wiring from the control can be regarded as antennae. …Cables or equipment carrying high voltage or frequency signals can pick up enough "noise" to cause either detectors or controls to initiate a false alarm.

> Properly engineered systems will greatly reduce or entirely eliminate the false alarm problem. (Solomon, 1986, p. 30)

It must be realized that smoke detector design spacing curves should not be utilized on non-smooth ceilings, including ceilings with pockets or projections from beams, supports, or trusses. (Bryan, 1982)

An analysis of the test methods for automatic fire detection devices in the U. S. reveals that the fact that different types and different sizes of fires are used to evaluate different classes of detectors. The result is a lack of comparison test data for each detector class and, as a consequence, intelligent decisions can not be made in the selection of automatic fire detectors for specific fire risks. (Bright, 1976, p. 1)

…provision of the computing power to handle and prioritize the thousands of signals which pass to and fro as sensors are addressed and control information issued,...providing the correct system status information...As the installation of the signaling and fire and security hardware is one of the last tasks during each construction phase…(Melhuish, 1988, p.?)

Historically the architecture of a system has related almost exclusively to the configuration of the systems wiring. With modern data transmission techniques the wiring is becoming less characteristic of a particular type of system, whereas the points within the system where the data is processed is becoming more significant. (Letts, 1997 p. 30)

The answer to Question 5 is, Which elements of a fire alarm system's design have the greatest potential to be misapplied? Improperly selecting of the system's appliances, the random placement of detectors and the unsophisticated approaches detection installation. Smoke detector design spacing curves being utilized on non-smooth ceilings, including ceilings with pockets or projections from beams, supports, or trusses. No standard used to evaluate detector selection because of the application use of different types and different sizes of fires used to evaluate the different classes of detectors. The design not accounting for excessive air-velocity, humidity, effect of temperature, condensation, dust, radio frequency interference, electromagnetic interference, transients, component failure, and marginal circuit design. External wiring to initiating circuits not being regarded as antennae, cables or equipment carrying high voltage or frequency signals, can pick up enough "noise" to cause either detectors or controls to initiate false alarms. Lack of proper selection for the operational characteristics of the individual detector type in relation to the related area protected, quantity of fuel, ignition sources, value of the property.

PROCEDURES

The research procedures used in this project began with a literature review conducted at the Learning Resource Center (LRC) at the National Fire Academy in February of 1999. Additional information was gathered and evaluated for the project under the Interlibrary Loan Program (ILL), located at the Laramie County Community College in Cheyenne Wyoming. The review concentrated on trade journals, fire magazines, fire alarm system codes and standards, and fire protection systems text books.

A literature review of the author's personal library was conducted, as well as review of Wyoming State Statute, Code of the City of Cheyenne, and fire department regulations and records. Personal interviews were conducted with an FPE, FPE Tech, and the Assistant Wyoming State Fire Marshal, a fire department plan reviewer, alarm contractors, electrical contractors, and fire alarm monitoring companies. Phone interviews were made with as many career fire department's plan reviewers around the Cheyenne region as was possible.

The larger fire department along the Front Range of Colorado are hiring FPE Technicians who have degrees in Fire Protection Engineering Technology, that most plan reviewers do not have specialized training in fire alarm systems, that most do not use a checklist or guide in the review of fire alarm plans, that the majority rely on the fire alarm designer to ensure a proper system is submitted, and in turn relies on the installer and fire alarm contractor to verify a competent fire alarm system before the final acceptance test by the fire department.

Definition of Terms

D.C. current. Direct electrical current.

Code. Includes mandatory requirements that are suitable for adoption into law.

Fire Protection Engineer. Is a person who is qualified by experience and education to perform fire protection system design, based on principles of physics, chemistry, thermodynamics, static's, dynamics, fluid dynamics, and upper level mathematics.

Fire Protection Technicians. Are those persons with the knowledge, skill, and training to perform fire protection layout, using accepted national standards.

Fire Protection System Design. Is based on engineering criteria that may not always coincide with criteria found in an accepted national standard.

Fire Protection System Layout. Is the act of following the requirements of a standard to execute a drawing.

Guide. Is informative but not binding.

Home Rule Authority. Authority delegated by the State for local municipalities to establish rules and regulations concerning code enforcement.

NICET. National Institute for Certification Engineering Technicians.

Practice of Architecture. Means rendering or offering to render service to clients generally, including any one or any combination of the following practices or professional services, advice, consultation, planning, architectural design, drawings and specifications, general administration of the contract as the owner's representative during the construction phase, wherein expert knowledge and skill are required in connection with erection, enlargement or alteration of any building or buildings, or the equipment, or utilities thereof or the accessories thereto, wherein the safeguarding of life, health or property is concerned or involved.

Recommended Practice. Provides non-mandatory advice.

Standard. Includes mandatory requirements used by an approving authority.

Research Methodology

An action research was conducted with the desired outcome being a fire alarm checklist and guide being produced to assist the fire department's plan reviewer in the review of fire alarm system construction plans.

Assumptions and Limitations

It was assumed that those individuals interviewed did in fact have substantial technical knowledge and background in the information they provided in their respective fields concerning different areas of fire alarm systems design, installation, maintenance, and monitoring.

It was assumed that the plan reviewers of fire alarm systems have at least some training in review of fire alarm systems and the expectation that they will be able to benefit from the use of the fire alarm checklist and guide.

The fire alarm code and respective standards have been able to keep pace with the rapid changes and advancements in the fire alarm systems equipment technology and the telephone utility services technology in fiber optic cable.

A limitation was the amount of current resource literature available concerning plan review of fire alarm systems, one does not exist.

RESULTS

A checklist and guideline that was produced for use by the fire alarm plan reviewer is shown in appendix A.

Answers to Research Questions

Research Question 1. What statutory codes, standards or rules apply to fire alarm system design and installation? Wyoming State Statute, City of Cheyenne Code, City Contractor Licensing Board rules, the 1997 Uniform Fire Code, NFPA 72 National Fire Alarm Code, NFPA 70, 90, 170 apply to fire alarm design and installation requirements.

Research Question 2. What specialized training or certification requirements are required or should be required for a fire alarm system designer, plan reviewer, contractor, installer and monitoring service companies? The certification requirements required to perform fire alarm system design were an FPE, EE, Fire Protection Engineering Technician, NICET IV Technician or national equivalent, NICET III for fire alarm system layout.

Research Question 3. How are the types of fire alarm systems to be installed in different occupancies determined? The Uniform Fire Code specifies the type of fire alarm system for installation in each different type of occupancy, as a manual, automatic, or combination of the two. NFPA 72 Fire Alarm Code specifies the types of alarm system monitoring types that the “Authority Having Jurisdiction” (AHJ) can specify for monitoring of the alarm system in the different occupancies. NFPA 72 also specifies the class of fire alarm system as either class A or B, A being a four wire redundant system, B being the normal two wire system, the (AHJ) and designer usually consider the type of occupancy for class A systems because they are more costly.

Research Question 4. What constitutes a complete and reliable fire alarm system? There are four main elements that make a fire alarm system complete and all are necessary to ensure its reliability they are “the system design, equipment appliance application, system installation, system maintenance.” Devices and equipment alone do not constitute a system until all component parts are properly inter-connected with electrical wiring. Therefore a more detailed look at pertinent codes and standards is required.

Research Question 5. Which elements of a fire alarm system’s design have the greatest potential to be misapplied? Improperly selecting of the system’s appliances, the random placement of detectors. Smoke detector design spacing curves being utilized on non-smooth ceilings, including ceilings with pockets or projections from beams, supports, or trusses. No standard used to evaluate detector selection because of the application use of different types and different sizes of fires used to evaluate the different classes of detectors. The design not accounting for excessive air-velocity, humidity, effect of temperature, condensation, dust, radio frequency interference, electromagnetic interference, transients, component failure, and marginal circuit design. External wiring to initiating circuits not being regarded as antennae, cables or equipment carrying high voltage or frequency signals, can pick up enough “noise” to cause either detectors or controls to initiate false alarms.

Unexpected Findings

The researcher discovered new requirements concerning the location requirements for smoke and heat detector placement and spacing limits. This was especially true for ceiling height limits and ceiling construction types.

The researcher discovered that the Wyoming State Statute's requirements for submittal of construction plans and the requirement for engineers stamp, is required for design of new buildings requiring a professional engineer's knowledge and professional background. There may be a conflict between the legal definition of practice of architecture and pre-engineered systems or layout work performed by a certified engineering technician. This may not necessarily pertain to pre-engineered systems and may not necessarily effect layout of fire protective systems.

DISCUSSION

The fire alarm checklist and guideline developed is specific to the Cheyenne Fire Department, as is the one of Orange County California according to Metz. The checklist developed specifies the appropriate method of monitoring of the fire alarm for each type of review performed in the City of Cheyenne's jurisdiction. The guideline explains location layout of smoke detector placement, heat detectors, visual appliance requirements and locations. This should clarify where the detectors should be located and a spacing layout. The study results were comparable to the findings of the CFD in the fact that most of the problem areas concerning fire alarm systems in the Cheyenne Fire Department were those listed or disgust by other authors cited in the research project. I was surprised that most fire departments don't have licensing control over installers of fire alarm systems.

Because a National Fire Alarm Code is utilized, all of the fire departments or people interviewed and the research results came up with the same method to establish the type of fire alarm system to be installed in the different occupancy classes.

Interviews indicated that maintenance of the fire alarm system was the most problematic characteristic. My believe is that of the four areas talked about by Saraduke the only one that poses a major problem to correct if missed is a proper fire alarm system design. It has a direct affect on the systems installation. With competent installers a properly designed system should be problem free. The design is the one area that really can't be corrected if missed at the review. Once installed improperly the system is very hard to correct. Problematic fire alarm systems can be fixed if the design and installation locations of the appliances are correct. The maintenance of the system and equipment application can be corrected.

The development of the fire alarm checklist and guideline may standardize the review of fire alarm plans within my organization. This will have to be evaluated. In any event a foundation should be established to ensure that qualified people doing the designs and installations are competent.

RECOMMENDATIONS

The Cheyenne Fire Department should implement and evaluate the checklist and guideline for a year. The checklist and guideline should provide some guidance of what the requirements are, show the legal flow for authority and give the reviewer an idea of where to find answers to questions they may have. Specialty training in fire alarm systems should be provided to each inspector in the Bureau that may be required to conduct the review. The plan reviewer should become ICBO certified as soon as practical. Hiring a FPE Technician who is ICBO certified to conduct plan reviews for the department at some point in the future should be considered and a staff study conducted to evaluate the cost effectiveness of doing so.

Legal research and an opinion are needed to determine the requirements for a Wyoming licensed engineer's stamp on all plans that are submitted for review. There is confusion of whether pre-engineered layout performed by a certified engineering technician constitutes design or if this is in fact layout as Gagnon indicates.

Research on a State by State basis is recommended, know what and from where your legal authority comes from.

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APPENDIX

Fire Alarm Plan Review Checklist and Guide

Submittal Requirements:

1. A NICET level IV designer at a minimum shall submit fire alarm system plans for design projects. They shall be submitted as a project package under a Wyoming Licensed Engineer's Stamp, unless the building falls under the exceptions listed in Wyoming State Statute for Architecture. Others permitted to submit plans would be a Fire Protection Engineer, or Electrical Engineer who must have knowledge and training concerning fire alarm systems design.

2. Fire alarm system plans layout, submitted for review shall be submitted by a minimum of a NICET level III technician.

3. Fire alarm plans shall indicate the location and method of alarm monitoring. All fire alarm systems shall be monitored at the 911 Emergency Center, (systems that have a monitoring requirement) unless phone utilities preclude this. They shall list the name of the monitoring and service contractors, addresses, phone numbers, and contract dates. Indicate whether remote monitoring at the 911 Emergency Center, Listed Central Station or Central Station.

4. A weatherproof Horn/Strobe appliance shall be placed over the FDC.

5. No public address system is permitted to notify occupants of a water flow alarm, horn/strobes are required throughout the building.

6. No pre-signal notification is permitted in the City of Cheyenne.

7. Alarm verification must have approval, (cross zoning) for smoke detector nuisance alarms. Reference NFPA 72, 3-8.2.3 & 3-8.2.5 must reduce spacing by 50%.

8. No smoke detectors are to be places in hoist-ways, unless the top of the elevator is protected by a fire sprinkler system.

9. All fire alarm system plans shall contain the following information for submittal:

(a) Designer or NICET Technicians license number.

(b) Provide three sets of current and complete prints for submittal, one set to be highlighted showing the fire alarm equipment, (style, type, model, ampere rating, voltage rating, and manufacture.)

(c) Normal construction print information, i.e., address, phone number, date, plan review number assigned by the Building Department.

(d) Equipment specifications for listed and approved fire alarm equipment with cut sheets submitted; decibel level and candela ratings shall be shown. The equipment list shall show type and quantity of appliances to be installed.
(e) Riser diagram showing all alarm and indicating zones, one line diagram, equipment and floor plan showing all appliance layout locations and the end of line resistor locations.
(f) Provide voltage drop calculations and battery calculations. Secondary power supply calculations shall specify the quantities, models, amperage, and wattage drawn by all equipment on each circuit for standby and alarm conditions.
(g) Provide the primary power supply information panel location and name breaker number and amperage of breaker. The fire alarm breaker shall be identified with in red permanent marking.
(h) Plans submitted shall be scaled, legible and contain only fire alarm systems information or systems related to the alarm system.
(i) A sequence of operation matrix shall be provided.
(j) All wiring shall indicate the type, size, manufacture, insulation type, whether solid or stranded and number of strands.

Fire Alarm Plan Reviewer Procedural Questions: (check if ok)

O 1. Is all of the required information submitted?
O 2. Are all areas specified, new and existing?
O 3. Are the General Notes accurate and appropriate?
O 4. Are there correct numbers of and types of initiating appliances present for device coverage, spacing for the area covered? Keep in mind (ceiling height, ceiling construction features i.e., beams type of ceiling, slope.
O 5. Do the areas have the proper type and quantity of notification appliances present?
O 6. Does the One Line Diagram show how the initiating appliance, notification appliance and ancillary control circuits are connected and function?
O 7. What method will be utilized to *sequence the strobe appliances used in each area?
O 8. Do the voltage drop calculations match the print layout for the alarm circuits; measure wire length of furthest circuit, check the quantity of appliances and current draw. Compare notification appliance type with these. Is the formula for the calculation shown on the print or calculation sheet, are they acceptable limits?
O 9. Do the values for the voltage drop and battery calculations match the cut sheet information submitted?
O 10. Can the control panel handle the charging requirements for the systems required calculated battery amp-hour draw? (17 amp-hour is the maximum for battery size)
O 11. Are the circuit outputs from the control panel or remote power supply, for the Notification appliances, exceeded for each individual zone?
O 12. Where is the annunciation panel's location? Is the annunciation panel justified for this project? Does the panel depict the proper zone descriptions?

O 13. Are automatic detectors provided? List type, spacing, ceiling height corrections, ceiling construction corrections, corrections from air velocity.
O 14. Are detectors provided in air handling units? What types of detectors are provided? Are they listed for the air velocities of the air handling units? Does activation of detector shut down the air-handling unit? Reference NFPA 90.
O 15. Are magnetic door releases and hardware utilized on any of the doors? What is the method of operation?
O 16. Does the fire alarm system activate elevator recall?
O 17. Do the sprinkler water flow appliances activate the building notification appliances?
O 18. Are the audible fire alarm appliances located to provide a minimum dBA sound level as required by NFPA 72.
O 19. Are local notification system's signs indicated on the print? Sign shall read Local Alarm. In Case of Fire Call 911.
O 20. Are manual pull stations located at each required exit, stairway, and required areas?
O 21. Is the fire alarm panel located at the main entrance? If not approval shall be required by the Fire Marshal for other location.
O 22. Are the system operational instructions indicated on the plans to be placed next to the fire alarm control panel?
O 23. Are the fire alarm symbols appropriate from NFPA 170, showing the fire appliances.

Smoke & Heat Detector Spacing Guidelines:

Most smoke detectors are designed for 900 sq. ft. maximum coverage, for 10-foot ceilings. The normal spacing is 30-feet center to center. Reference NFPA 72, 5-2.4 for smooth ceiling spacing, irregular areas, high ceilings, solid joist construction, beam construction, sloped ceilings. Room layout must start at each corner of the room, rule S/2 or 30-ft / 2=15-ft. perpendicular from each wall is first smoke detector layout then 30-ft spacing in between detectors.

Heat detectors normal spacing is 50-ft.

<u>Corridors and hallway layout</u>, in no case can the smoke or heat detectors exceed 41-ft. center to center spacing, or exceed 21-ft. from the most distant protected point, last detector spacing. Reference NFPA 72 (A-5-2.4.1) figure.

Reference NFPA 72 (A-5-2.4.1.1) figure, for <u>Irregular room shape.</u>

Use NFPA 72 table (5-2.4.1.2) to reduce smoke detector spacing for ceilings higher than 10-ft. up to 30-ft. *note exceptions for certain type of detectors can't be used.

Use NFPA 72 (A-5-2.4.4.1) figure, for smoke detector layout on sloped ceilings, peaked type.

Use NFPA 72 (A-5-2.4.4.2) figure, for smoke detector layout on sloped ceilings, shed type.

- Note side wall mounted smoke detectors must be a minimum of 4-inches from the ceiling to a maximum of 12-inches from the ceiling to the top of the detector. Reference NFPA 72 (A-5-2.2.1).

Smoke detector locations for door releases, use NFPA 72 (5-10-7) and 5-10.7.4.1.1 table.

Beams & Joist on Ceilings, Layout:

Heat Detectors:

For joist ceilings (obstructions that are 3-ft. or less apart), reduce the spacing perpendicular to the joist by half for heat detectors and locate the detector on the bottom of the joist. Reference NFPA 72 (5-2.2.1) exception.

For beamed ceilings (obstructions that are 3-ft. or less apart), use the following guidelines:

For heat detectors, if the beams project more than 4-inches below the ceiling, reduce the space by 1/3. Reference NFPA72 (5-2.4.3).

If the beams are less than 12-inches deep and less than 8-ft. apart, heat detectors may be mounted either on the ceiling or the bottom of the beam. Reference NFPA 72 (5-2.2.1) exception 2.

If the beams are more than 18-inces deep and more than 8-ft. apart, treat each bay as a separate area requiring at least one spot-type detector. Reference NFPA 72 (5-2.4.3).

Smoke Detectors:

For non-smooth ceiling applications, a continuous ceiling obstruction greater than 12-inches deep (4-inches for heat detectors) requires an adjustment in the spacing of the detectors in the direction perpendicular to the obstruction. Reference NFPA 72 (5-2.4.2, 5-2.4.3, 5-3.4.6.1).

For joist ceilings (obstructions that are 3-ft. or less apart) 12-ft. or less high, reduce the spacing perpendicular to the joist by half for smoke detectors and locate the detectors either on the ceiling or on the bottom of joist. Reference NFPA72 (5-3.4.6.1).

If beams are more than 12-inches deep or ceiling height exceeds 12-ft., treat each bay as a separate area, requiring at least one spot-type detector per bay. Reference NFPA 72 (5-3.4.6.1 b).

- Note watch for the environmental concerns: heat, dust, airflow, vibration, radio frequency, electrostatic discharge, intense light. Never place a smoke detector closer than 3-ft. of a supply diffuser, clean forced air may prevent smoke from reaching the detector. Reference NFPA72 (5-3.5.1, A-5.3.5.1).

Average Ambient Sound Levels:

Business Occupancies………………………..55dBA
Education Occupancies……………………….45dBA
Industrial Occupancies………………………. 80dBA
Institutional Occupancies……………………..50dBA
Mercantile Occupancies………………………40dBA
Places of Assembly…………………………...55dBA
Residential Occupancies………………………35dBA
Storage Occupancies…………………………..30dBA

- Note 70 dBA minimum is required at the pillow.

Location of ADA Visible Appliances:

80-inches above the floor or 6-inches below the ceiling, whichever is lower.
No place in any room more than 50-ft. from an appliance.
Large rooms, appliances may be on 100-ft. centers around the perimeter of the room.
At a minimum, visible appliances required in;
Restrooms
General usage areas (meeting rooms)
Hallways

ADA Requirements for Hotel/Motel:

8 appliances for first 100 rooms
4 appliances for additional 100 rooms
2 appliances for each 25 rooms being remodeled.

Visible Alarm Notification Appliances:

ANSI Standard A117.1 requires visible appliances to be:

A minimum of 15 candela in non-sleeping areas.
A minimum of 110 candela in sleeping areas.
A minimum of 177 candela if combined with a single station smoke detector.
Note NFPA 72 contains similar requirements.

Installation one or two strobes on opposite walls but in rooms, 80-ft. x 80-ft. or greater, where more than 2 strobes are in a field of view, space the strobes a minimum of 55 ft. apart or you must synchronize them.

Spacing of strobes.

A maximum spacing of 100 ft. between appliances on the perimeter walls is allowed. See NFPA 72 table (6-4.4.1) for proper layout coverage in large square rooms.

Use NFPA 72 table (6-4.4.1.1 b) for room spacing of ceiling mounted visual strobe appliances. This table provides the minimum candela output requirement based on ceiling height and gives the spacing reductions necessary.

Wall mounted strobe appliances are to be mounted a minimum of 80-inches off of the floor to a maximum of 96-inches off of the floor, measured to the bottom of the appliance.

Ceiling mounted appliances are allowed up to 30-ft. ceiling height, after 30-ft., the appliances must be suspended to the 30-ft. level or less.

<u>This checklist and guide is not all inclusive. You are required to consult the appropriate Codes and Standards to verify their applications!</u>